UNIVERSITY OF PENNSYLVANIA

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IN PSYCHOLOGY

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

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THRESHOLDS FOR THE PERCEPTION OF DIFFERENCE IN FACIAL EXPRESSION AND ITS ELEMENTS

By Francis W. Irwin, University of Pennsylvania

No one can be so averse to analysis as to deny that there are degrees of generality among perceptions—for example, that one may perceive a tree and that he may also perceive the trunk of the tree, or a branch, or a leaf on that branch, or a vein in that leaf. In the same way, it is possible to perceive the expression of a face as a whole, or the peculiarities of the contours of the features—curve of lips, lines about the eyes, mouth, forehead, etc.—which are present at the same time. Now, one may say that a particular facial expression presupposes the existence of a certain disposition of these curves and lines upon the face, and no more assert that the expression *is the sum of them* than we should affirm that a tree is merely the sum of the trunk, branches, and leaves, or even of the cells into which we may analyze these parts under the microscope. We may call the expression the more general, and the curve of the lips or the creases at the corners of the eyes or the lines in the forehead the more particular, perception in this instance. But, if the perception of variations in expression be admitted to presuppose the *existence* of variations in these particulars, must it also presuppose the *perception* of them?

It is obvious that in the case, let us say, of a lump of metal the perception of the lump does not mean the perception of the indefinitely minute parts into which it can be divided; but this is not a correct analogy, since a smile is not composed of a large number of tiny smiles. Is it not possible, however, that a smile might be perceived

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when the changes in the curves and lines essential to it are imperceptible—reminding us of the visible grin of an invisible Cheshire cat? Common opinion seems ready to agree that such a thing not only is quite possible but happens continually,[1] that we often perceive things which can be analyzed into parts of a heterogeneous nature, parts which are not perceived singly; but of course our question is: *Can* they be perceived singly, whenever the more general perception is possible?

The experiment here reported deals with the difference thresholds of these two perceptions. The problem may be stated: to investigate the relationship between the thresholds for the perception of differences in facial expression and those for the perception of differences in certain elements of the expression. Sander in a review of the experimental results of the *Gestalt* psychology has indicated that the configuration in which a particular element is found may have an important bearing upon the difference threshold for this particular. He states that "die Unterschiedsschwellen abhängig sind von den jeweiligen Gestaltbedingungen, ... die Empfindlichkeit für Gestaltveränderungen im allgemeinen grösser ist als für Veränderungen isolierter Gegebenheiten." For example, "die Unterschiedsempfindlichkeit für Distanzveränderungen zweier Punkte ist erheblich gröber, wenn sie isoliert, als dann, wenn sie etwa als Pupillen eines Gesichtes dargeboten werden."[2] Similarly, Bühler reports that the difference thresholds for perception of the length of a line are higher than those for the perception of the difference between right angles in which this line forms the varying side.[3]

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[1]Cf. E. A. Singer, Jr., Studies in sensation and judgment, *Psychol. Rev.*, 4, 1897, 265. "It is well-known that where differences exist, comparatively slight in nature, between objects of considerable complexity of structure (such as human faces) one may be quite aware of a difference without being able to tell in what the difference consists." The conclusion of this experiment is that "the general judgment of difference has a lower threshold than the particular" (p. 271). The "general judgment" is defined as that judgment of difference "which cannot be explained as due to chance and to complete appreciation of the particular differences presented" (p. 270).

Cf. also Max Wertheimer's suggestion that a difference may be perceived without the ability to tell in what the difference consists. Untersuchungen zur Lehre von der Gestalt, *Psychol. Forsch.*, 4, 1923, 318.

Grace A. DeLaguna, Dualism and Gestalt psychology, *Psychol. Rev.*, 37, 1930, 200, says: "The little child . . . . . perceives and responds to a 'smiling face' before it has learned to see the curves of lip and cheek which compose it geometrically."

[2]F. Sander, Experimentelle Ergebnisse der Gestaltpsychologie, *Ber. u. d. X Kongr. f. exper. Psychol.* (Bonn), 1927, 46 f.

[3]K. Bühler, *Die Gestaltwahrnehmungen*, I, 1913.

So far as I have been able to ascertain, however, no one has experimented upon this relationship as it holds in the same figures with varying attitudes of the subject induced by different types of instructions.[4] It is toward this that the present experiment is directed. No attempt is here made to define "smiling," "frowning," or "neutral" expressions, but it will be shown that all the *S*s agreed in their choice of the direction of curvature which was toward smiling and that which was toward frowning, without any instruction upon the point. This agreement was sufficient for the purposes of the experiment.

Method

Apparatus. Five sets of cards, A, B, C, D, and E were used, each set consisting of 3 identical series of 7 cards. The cards were 91 mm. squares of stiff cardboard with a white unglazed surface.

Material A consisted of cards upon which were diagrammatic ('Leonardo') faces. Examples are given in Plate 1. A circle 46 mm. in diam. was in the center of each card: the nose was represented by a straight line 7 mm. long with its lower end at the center of the circle; two horizontal lines (straight or curved) 10 mm. long and 10 mm. apart on a line 8 mm. vertically above the center of the circle represented the eyes; while a horizontal line (straight or curved), 10 mm. in length and 14 mm. vertically below the center of the circle, represented the mouth. All these lines were of the same breadth, approximately 'one point face' (0.35 mm.). The variations in the 7 different cards in each of the 3 series composing this set may be described as follows:

Card 1—eyes and mouth arcs of 3 cm. radius concave upwards;
Card 2—eyes and mouth arcs of 6 cm. radius concave upwards;
Card 3—eyes and mouth arcs of 12 cm. radius concave upwards;
Card 4—eyes and mouth straight lines;
Card 5—eyes and mouth arcs of 12 cm. radius concave downwards;
Card 6—eyes and mouth arcs of 6 cm. radius concave downwards; and
Card 7—eyes and mouth arcs of 3 cm. radius concave downwards.

Thus we have a series from greatest 'upward' curvature through the straight line to greatest 'downward' curvature. This material may be referred to as the *full face.*

Material B differed from Material A only in that here the mouth alone varied, the eyes remaining straight. This material may be called the *mouth face.*

Material C consisted of cards upon which there was but a single horizontal line, in the center of the card. This line was 10 mm. long and varied in curvature just as did the varying lines of Materials A and B.

Material D consisted of the cards of Material A, inverted.

Material E consisted of the cards of Material B, inverted.

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[4] R. K. White and Carney Landis have measured the least perceptible differences of variation in a silhouette, but seem not to have attacked the problem of the threshold for differences in facial expression. See The perception of silhouettes, this JOURNAL, 42, 1930, 431-435.

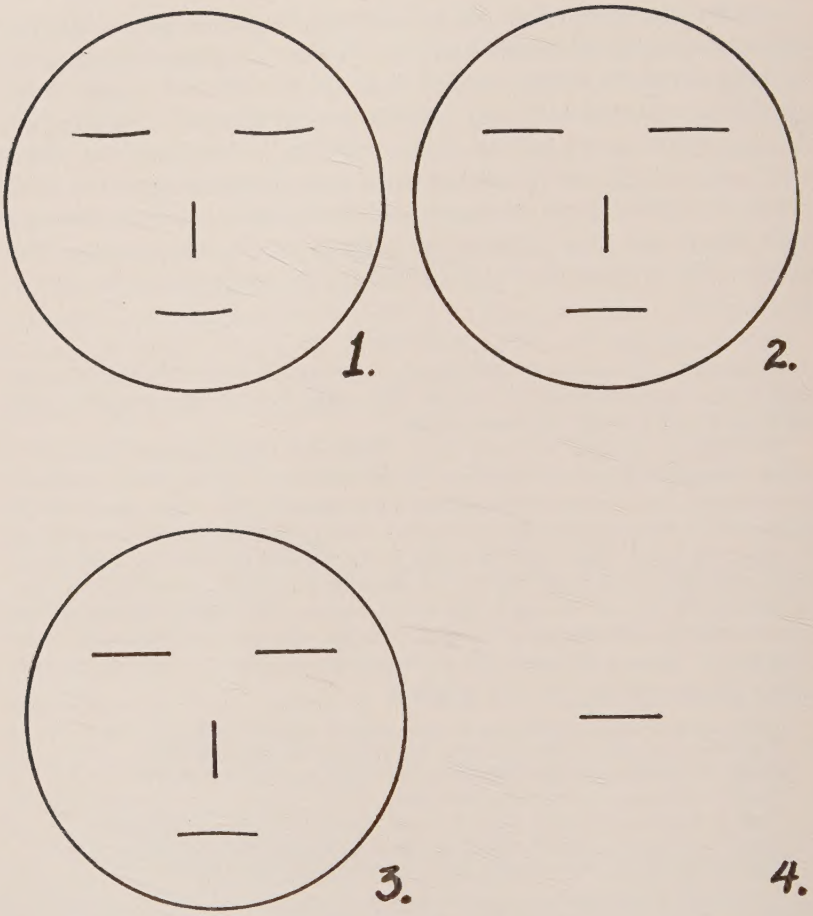


PLATE I. MATERIALS

Key: 1 = Card 1, Material A; 2 = Card 5, Material A; 3 = Card 6, Material B; 4 = Card 4, Material C. The figures are reproduced actual size, but, when used, each figure was centered on a card 91 mm. square.

These figures were originally drawn full size by a professional draughtsman, and were then photo-engraved, with the use of a prism to prevent distortion, finally being printed upon the cardboard in black. The cutting was done by machine.

Lest dust or smudges of any kind lead to recognition of particular cards a large number were at hand, and sets were often replaced. Several times a *S* reported the belief that he could recognize a particular card; he was then told to report when next he saw the card, but in no instance was he successful in doing this.

The cards were exposed for a period of 0.18 sec. by means of a Whipple tachistoscope.[5] Care was taken to keep constant the lighting of the instrument.

The experiment was carried on from December 17, 1929, to May 21, 1930. Until February 3 the photographic dark-room of the Laboratory of Psychology at the University of Pennsylvania was used; it was then necessary to move to a room in the Hare Laboratory of Chemistry where lighting conditions were considerably different. However, no variations in the results that could be attributed to this change were noticed.

Procedure. The instructions used are presented below. It will be noted that there are two general types, (I) for 'curvature' and (II) for 'expression.' Type I necessarily varied slightly according to the material employed. Type II was the same for each material.

Instructions IA. You will be shown a series of diagrams of faces, each diagram being given but a short exposure. In some of the diagrams the eyes and mouth will be arcs turned upwards at the ends, in others, arcs turned downwards, and in others they will be straight lines. You are to make an immediate judgment for each diagram, reporting the eyes and mouth to be turned upwards, turned downwards, or straight, by saying 'up,' 'down,' or 'straight.' Be sure to make a judgment on each diagram and to state it immediately. I shall say 'ready' a short time before the exposure of each face, and 'now' just as it is about to appear.

Instructions IB. You will be shown a series of diagrams of faces, each face being given but a short exposure. In some of the diagrams the mouth will be an arc turned upwards at the ends,[6] in others an arc turned downwards, and in others it will be a straight line. You are to make an immediate judgment for each diagram, reporting the mouth to be turned upwards, turned downwards, or straight, by saying 'up,' 'down,' or 'straight.' Be sure to make a judgment on each diagram and to state it immediately. I shall say 'ready' a short time before the exposure of each face, and 'now' just as it is about to appear.

Instructions IC. You will be shown a series of lines, each line being given but a short exposure. Some of the lines will be arcs turned upwards at the ends, others, arcs turned downwards, and others will be straight lines. You are to make an immediate judgment for each line, reporting it to be turned upwards, turned downwards, or straight, by saying 'up,' 'down,' or 'straight.' Be sure to make a judgment on each and line to report it immediately. I shall say 'ready' a short time before the exposure of each line, and 'now' just as it is about to appear.

Instructions ID. You will be shown a series of figures, each figure being given but a short exposure. Included in each figure will be three horizontal lines, some of which will be arcs turned upwards at the ends, others, arcs turned downwards, and others will be straight lines. You are to make an immediate judgment for each figure, reporting the lines to be turned upwards, turned downwards, or straight, by saying 'up,' 'down,' or 'straight.' Be sure to make a judgment on each figure and to report it immediately.

It may be remarked that calling the inverted face a "figure," as in the preceding and following instructions, did not at all succeed in abolishing the idea of "face." Each of the 5 *S*s thought it a good joke as soon as the "figure" was shown.

Instructions IE. You will be shown a series of figures, each figure being given but a short exposure. Included in each figure will be three horizontal lines. The

[5]Described in G. M. Whipple, *Manual of Mental and Physical Tests*, I, 1914, 264.

[6]"Upwards at the ends," etc., seemed the simplest way of indicating the direction of curvature of the arcs, a rather awkward thing to make clear without danger of confusion. The *S*s seemed to understand perfectly what was meant.

lower two will always be straight, but the upper one, in which you are interested, will sometimes be an arc turned upwards at the ends, sometimes an arc turned downwards, and sometimes a straight line. You are to make an immediate judgment on each figure, reporting this line to be turned upwards, turned downwards, or straight, by saying 'up,' 'down,' or 'straight.' Be sure to make a judgment on each figure and to report it immediately.

Instructions II. You will be shown a series of diagrams of faces, each face being given but a short exposure. For each face you are to make an immediate judgment, as to whether it is smiling, frowning, or neutral. Be sure to make a judgment on each diagram and to state it immediately, remembering to judge only as to whether the face is smiling, frowning, or neutral, using the terms 'smile,' 'frown,' or 'neutral' in your report. I shall say 'ready' a short time before the exposure of each face, and 'now' just as it is about to appear.

The appropriate instructions were read to the *S* at the start of each experimental period, the sentence concerning the 'ready—now' signals being omitted after several sittings.

The *S* sat at a constant distance from the tachistoscope; the front legs of the chair were 2 m. from the machine. The 'ready' signal was given about 2 sec., and the 'now' signal 1 sec., before the exposure of the card.

Two orders of presentation of the 21 cards in a set of material were employed. The first was used while obtaining the first two difference-thresholds, and thereafter the first and second were alternated for each DL, the alternation beginning with the second order. The orders were as follows (the numbers being those of the cards as given above in the description of the material). First: 3, 1, 4, 7, 6, 2, 5, 1, 3, 7, 2, 4, 6, 5, 2, 6, 4, 7, 3, 1, 5; Second: 5, 7, 3, 1, 4, 2, 6, 7, 2, 4, 5, 1, 3, 6, 1, 4, 6, 3, 7, 5, 2. The use of these two orders precluded the possibility of the learning of the order of presentation. No *S* was able to demonstrate his having learned even a part of a series, though several tried to do this at various times.

Eleven DL were obtained from each *S*. Each DL was calculated from 50 observations of each of the 7 different cards in a set of material, with the exception that in the following cases 100 judgments of each card were obtained: *A*—the first 4 DL; *C* and *H*—the first 2 DL; *Ot* and *R*—the first 3 DL.

Thus, the results include for the 5 *S*s a total of 24,150 judgments. From 217 to 231 judgments were obtained at each experimental session. No DL was completed in a single sitting, and the exceptions noted above required three. An intermission of from 5 to 10 min. was introduced when each session was about half completed, usually after 6 series of 21 judgments had been made. An experimental period, including the intermission, usually lasted about 50 min.

Subjects. The *S*s in this experiment were Mr. Leon Arons (*A*), Dr. Stanley F. Cooper (*C*), Dr. John F. Humes (*H*), Mr. Jay L. Otis (*Ot*), and Mr. Thomas W. Richards (*R*)[7]. With the exception of *A*, a graduate student in psychology, the *S*s were members of the Department of Psychology at the University of Pennsylvania. *A*, *C*, and *H* were already familiar with tachistoscopic procedure; *A* and *C* had served in the preliminary experiment carried on to determine the details of the method to be followed in the main experiment, while *C* and *H* had been

[7]The author desires to acknowledge his indebtedness to these friends for their patience, and to Dr. G. H. Clark and Messrs. W. L. VanBuskirk and F. R. Gillespie, who served in the preliminaries to this experiment; and in particular to Professor Samuel W. Fernberger for his constant direction and encouragement.

TABLE I

SHOWING, FOR EVERY *S*, THE DL AND MEASURES OF PRECISION FOR EVERY ONE OF THE VARIOUS EXPERIMENTAL CONDITIONS

S		1	2	3	4	5	6	7	8	9	10	11
	Condition	IA	IIB	IC	IIA	IB	ID	IIA	IIA	IE	IC	IIA
	DL	1.0	1.5	1.0	1.3	0.9	0.5	1.6	1.2	0.2	0.3	1.3
A	h_1	0.30	0.26	0.37	0.29	0.38	0.52	0.47	0.40	0.43	0.54	0.45
	h_2	0.25	0.24	0.37	0.26	0.35	0.51	0.42	0.41	0.42	0.55	0.38
	Condition	IIA	IB	IIA	IC	ID	IIB	IA	IIA	IB	IIA	IE
	DL	1.4	1.4	1.2	1.1	1.3	1.2	1.1	0 8	0.7	0.6	1.3
C	h_1	0.25	0.34	0.41	0.44	0.59	0.36	0.45	0.43	0.46	0.55	0.34
	h_2	0.30	0.35	0.41	0.48	0.55	0.39	0.54	0.41	0.47	0.71	0.45
	Condition	IB	IIA	ID	IC	IIB	IA	IIA	IE	IIA	ID	IIB
	DL	1.3	1.0	1.0	1.5	0.7	0.8	0.6	0.7	0.6	0.8	0.7
H	h_1	0.24	0.33	0.43	0.54	0.31	0.52	0.39	0.40	0.41	0.49	0.44
	h_2	0 22	0 35	0.45	0.66	0.39	0.52	0.43	0.34	0.42	0.56	0.47
	Condition	IC	IIB	IIA	ID	IB	IIA	IA	ID	IIA	IE	IA
	DL	1.0	0.7	0.4	0.4	0.8	0.6	0.5	0.7	0.7	0.8	0.6
Ot	h_1	0.37	0.36	0.62	0.87	0.45	0.64	0.62	0.91	0.94	0.51	0.69
	h_2	0 37	0.34	0.64	1.01	0.64	0.65	0.68	0.81	0.45	0.65	0.98
	Condition	IIB	IA	IIB	ID	IIA	IE	IC	IIA	IB	ID	IIA
	DL	2.7	2.2	3.3	2.3	2.6	2.6	2.4	2.3	2.6	2.6	2.3
R	h_1	0.30	0 31	0.37	0.52	0.60	0.45	1.03	0.79	0.51	1.87	0.67
	h_2	0.19	0.32	0.21	0.46	0.55	1.17	0.83	0.84	0.79	0.63	0.37

Ss in other experiments in which the tachistoscope was used. The *Ss* were examined by an oculist, who reported normal or normally corrected vision in each case. None of the *Ss* had any information as to the purpose of the experiment.

Results

The results obtained by this method were treated in accordance with the phi-gamma hypothesis. Eleven difference-thresholds were obtained for each *S*. These DL and their coefficients of precision h_1 and h_2 are incorporated in Table I. Table II gives the DL for each *S*

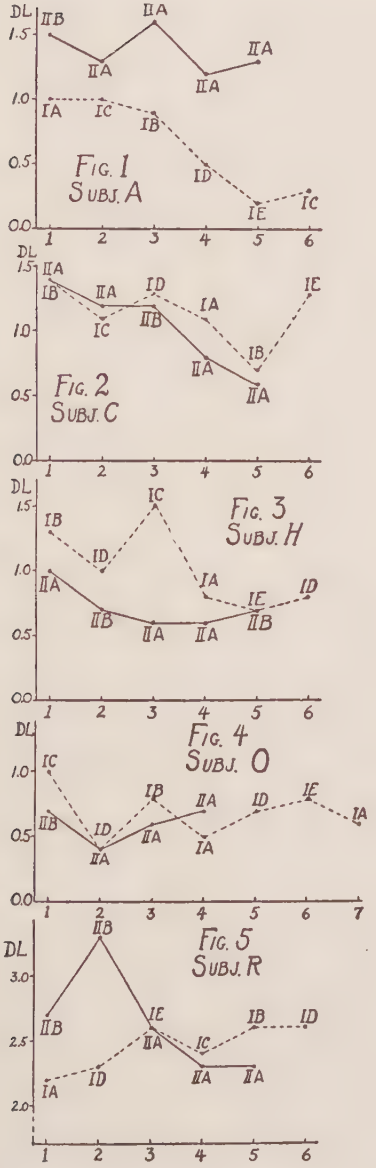
TABLE II

Showing, for Every *S*, the DL Arranged According to Their Experimental Conditions

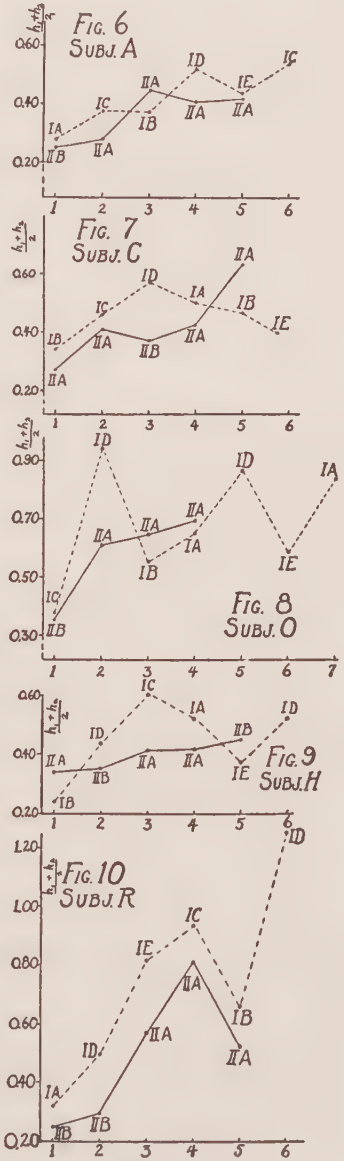
	Conditions						
S	IA	IIA	IB	IIB	IC	ID	IE
A	1.0	1.3	0.9	1.5	1.0	0.5	0.2
		1.6			0.3		
		1.2					
		1.3					
C	1.1	1.4	1.4	1.2	1.1	1.3	1.3
		1.2	0.7				
		0.8					
		0.6					
H	0.8	1.0	1.3	0.7	1.5	1.0	0.7
		0.6		0.7		0.8	
		0.6					
Ot	0.5	0.4	0.8	0.7	1.0	0.4	0.8
	0.6	0.6				0.7	
		0.7					
R	2.2	2.6	2.6	2.7	2.4	2.3	2.6
		2.3		3.3		2.6	
		2.3					

arranged as to the conditions (instructions and material) under which they were obtained.

In Figs. 1 to 5 are represented the DL for each *S*. The broken lines connect those for 'curvature' and the solid lines those for 'expression.' The ordinates represent the amount of the DL, and the abscissae give the order of succession of the various DL under each set of instructions. The notations at each point give the conditions



FIGS. 1-5. DL FOR EVERY *S*



FIGS. 6-10. COEFFICIENTS OF PRECISION FOR EVERY *S*

Broken line connects values for 'curvature;' solid line connects values for 'expression.'

under which that DL was obtained. Thus in Fig. 1 we find that *A*'s first 'expression' limen, obtained with Material B and Instructions II, amounted to 1.5, while his second 'expression' limen, with Material A and Instructions II, amounted to 1.3. Figs. 6 to 10 are a similar representation of the coefficients of precision, the average of h_1 and h_2 for each DL being graphed. In calculating the DL no absolute units of curvature were used. The stimulus intervals were regarded as equal to unity; hence the magnitudes of the DL and the h are in this sense arbitrary.

TABLE III

JUDGMENTS OF MATERIAL A UNDER CONDITIONS UNRESTRICTED AS TO TIME AND DISTANCE

	Subject				
	A	*C*	*H*	*Ot*	*R*
UP	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3
DOWN	5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7	5, 6, 7
STRAIGHT	4	4	4	4	4
SMILE	1, 2	1, 2, 3	1, 2, 3	1, 2, 3	1, "perhaps" 2
FROWN	7	5, 6, 7	5, 6, 7	5, 6, 7	7
NEUTRAL	3, 4, 5, 6	4	4	4	3, 4, 5, 6

In some cases the *S*s were asked to write introspections, although no suggestion as to their content or purpose was offered. Quotations from some of these reports will be presented in the discussion; and in view of their importance it is to be remembered that they were absolutely undirected.

At the conclusion of the experiment, a complete series of the 7 different cards of Material A was laid before each *S* individually, after the cards had been shuffled. *S* was then asked to judge each card as 'up,' 'down,' or 'straight,' an indefinite amount of time and as close observation as desired being permitted. When these judgments had been made, the cards were again shuffled, laid before the *S*, and judgments of 'smiling,' 'frowning,' or 'neutral' requested. The results of this experiment are recorded in Table III.

DISCUSSION

In the first place, it is obvious that under the conditions of the experiment the middle category *neutral* is essentially more elastic than the middle category *straight*. No line which is perceived as curved can rightly be judged as *straight*; yet it is quite in harmony with

the instructions, since no criterion of expression was imposed, to judge as *neutral* faces in which curvature of the lines was clearly perceived. The *neutral* category was also a much more convenient place to unload all doubtful judgments than the category *straight*. That at least 2 *S*s very probably took advantage of this elasticity is evident from Table III. *C*, *H*, and *Ot* under the conditions described judged as *smiling* each card perceived also as *up*, as *frowning* each card perceived as *down*, and as *neutral* the card perceived as *straight*. But though *A* and *R* were as accurate as the others in their judgment of curvature, they were not willing to attribute expression to all faces in which curvature was perceptible. Thus, *A* judged card 4 alone as *straight*, but cards 3, 4, 5, and 6 as *neutral*; while *R*, also judging card 4 alone as *straight*, judged cards 3, 4, 5, and 6 as *neutral* and card 2 as "perhaps" *smiling*.[8] The natural result of these tendencies, if carried into the main experiment, would be to make the DL for expression relatively greater than those for curvature in the case of these 2 *S*s. This presumption can be seen from Table II to be verified for *A*, whose DL were in general quite low; but it is doubtful as far as *R* is concerned—possibly because of the magnitude of his DL, which indicates his having had much difficulty in perceiving any differences at all except at the extremes of the stimulus series. From these considerations we may conclude that the experiment from its very conditions favored lower DL for curvature than for expression.[9]

'Learning,' as indicated by a downward tendency of the thresholds or by an upward tendency of the 'precision' might be due chiefly, first, to general adjustment of *S* to the conditions of the experiment; and, secondly, to the attainment of greater stability in his criteria of judgment. The first tendency might reasonably be expected to show itself in large measure only during the early part of the experiment, for 3 sittings of almost an hour apiece were required for each of the first 3 or 4 DL for each *S*. (Besides, *A* had observed in a period of 4

[8]It may be noted that there was complete agreement as to the extremes and the middle, card 1 being in all cases judged "smiling," card 7 "frowning," and card 4 "neutral." This relationship held also in the main experiment, the upper threshold always being that for "smiling" and the lower that for "frowning," while the point of subjective equality varied little from 4.

[9]Cf. S. W. Fernberger, The use of equality judgments in psychophysical procedures, *Psychol. Rev.*, 37, 1930, 110 f.: "This is the real difference between the equality and the difference judgments. The difference judgments are much more 'objective' in nature. The equality judgments are more dependent on the attitude of the observer, on the form of instruction, on the observer's understanding of instructions and, as Angell pointed out, to an extent, at least, on his basic temperament."

sittings, and *C* in 6 sittings, during the preliminary work.) New types of material were introduced, however, at various times, so that the difficulty of establishing criteria should have been somewhat extended, perhaps over the whole course of experimentation.

As indicated in Figs. 1 to 5, these tendencies were variable. *A* shows a marked trend toward greater stability of criterion in the limens of curvature, and a much slighter one in the thresholds for expression. The advantage at both start and finish lies with curvature.

C shows a trend toward increased stability for expression which is emphatic; his series for curvature is more uncertain, though it is in general in the same direction except for a reversal in the case of the last DL. Here the advantage is with expression after equality at the start.

In the case of *H*, there is a more evident improvement in the criteria for curvature than in those of expression. The last 3 DL for each are practically constant.

The tendencies of *Ot* are indecisive. A sharp drop at the beginning is more or less neutralized thereafter.

R's criteria for expression show great improvement with the introduction of the *full face*, but his series for curvature has a general upward movement—the only case in the results which indicates decreasing precision of criteria.

In brief, then, in two cases, *A* and *H*, the criteria of curvature show a greater tendency toward precision than those of expression; for two other cases, *O* and *R*, the expression series shows more marked gain in stability than does the curvature series; *Ot*'s results show little improvement for either; and there is one case of a trend toward decreased stability, *R*'s curvature series.

It must already be evident that in spite of the large number of judgments upon which the DL are based, the variability is of such magnitude as to preclude statistical reliability for the differences among DL. The results must, then, be taken as suggestive rather than conclusive, certain tendencies being at least sufficiently marked to justify their being discussed.

The coefficients of precision (h_1 and h_2) in all cases show a general tendency toward improvement, as may be seen in Figs. 6-10. The curvature judgments have on the whole considerably less scatter for each *S* than have the expression judgments; but, on the other hand, for *C*, *H*, and *Ot* the precision increases more steadily for expression than for curvature, while for *A* and *R* the two increase at about the

same rate. In general, the precision for curvature, while greater than that for expression, is also more variable.

Since the variability is so great, it is difficult with 5 different types of material and only 11 DL for each *S* to determine the effect of these differences of material. The *full face*, whether upright or inverted, seems to give lower limens than the *mouth face* or the *single line*; but as between the two latter there appears little difference, excepting in the case of the *mouth face* with instructions for expression, which gave in general the highest DL. From Table II it can be seen that only for *H* did the *mouth face* with instructions for expression rank higher than fourth among the 7 different conditions, and that in two cases it ranked last. Evidently the *mouth face* is not as expressive as the *full face.*

One would likely suppose *a priori* that the thresholds would be lower when there were 3 lines by which to judge instead of one, and that it would be easier to judge the expression of a face with eyes and mouth varying than that of a face with the mouth alone varying. The fact that, in spite of the variability and of the small number of DL relative to the number of conditions, the indications are in line with such apparently reasonable expectations justifies confidence in the reliability of the results.

Perhaps the most interesting comparison is that concerning the effects of the two types of instructions, those for curvature (Instructions I) and those for expression (Instructions II). Fig. 1 shows *A*'s results. The successive DL under instructions to judge curvature are connected by the broken line, and those for expression by the solid line. It can be seen that *A*'s thresholds for curvature are considerably lower than those for expression, for there is not even an overlapping of the two curves. That *A* should have given such results is quite in accord with the fact that he tended to demand an easily perceptible curvature before he would judge the face as having any but a *neutral* expression. His introspections give some cues as to his criteria. After his first observation period, under conditions IA, he wrote:

I usually fixated the left eye. . . . . It was most infrequently that I saw the mouth. . . . . Occasionally both eyes appeared distinct—at times but one.

Under conditions IIB (his second threshold) he wrote:

I find myself using at least three criteria: (a) distance between eyes and mouth if great usually a frown,—if very short, a smile,—in between, guess frown or smile or neutral; (b) whether mouth was curved up or down: up—a smile, down—a frown; (c) length of mouth: if very short or curved (noticeably down), a frown; medium even when slightly curved, neutral; long, if curved up, a smile, if curved down, a frown. I used these (and others I don't remember) singly, together, etc., now one, now another.

The "medium, even when slightly curved, neutral" is significant, as is the evident difficulty he had in establishing a criterion of expression. No other light upon his criteria appears in his introspections.

Ot's results (Fig. 4) are not clear-cut, though what advantage there is appears to be in favor of expression. No introspective evidence as to his criteria is available.

It will be remembered that at the end of the experiment *R* showed, as did *A*, the tendency to demand much apparent curvature before judging the face as expressive. *R*'s thresholds (Fig. 5) are by far higher than any of the other *S*s', both for expression and for curvature; the upper and lower thresholds are near the limits of the stimulus series. His first two expression limens, with the *mouth face*, are considerably above the first two curvature limens, but, when the *full face* was introduced, the DL for expression dropped and fell below the succeeding curvature DL, though never quite reaching the low level of the first curvature DL. In an introspection upon the first DL (IIB) he stated:

Usually I fixate the mouth, often the eye-brows, but I try to see the thing as a whole.

On the second DL (IA) he wrote:

Since starting on the second series several things have occurred to me. I did not have a clear idea of the precise criterion for judging U, D, or S but it gradually became apparent. The first few times I judged them by the curvature of the single eyebrow, usually by the one on my left. Today I found that I was judging by looking at the eyebrow on my right, and at the right end. I tried to use the same method I had been using but could not seem to do so. Perhaps a limited distribution of attention prevents me from seeing the image as a whole and judging from that, for I cannot seem to do so in the short interval allowed.

C's results (Fig. 2) show a tendency in favor of keener sensitivity for expression than for curvature, after approximate equality at the start. Apparently enjoying the experimental session, he would often, when under instructions to judge expression, make such exclamations as, "Oh, what an ugly frown!" or "What a nice broad smile!" We have noted that *C* served as an *S* in the preliminary study when the procedure for this experiment was being worked out. At the first sitting of this preliminary work he was judging the curvature of a single line, and his introspection at the close of the period is of interest. He wrote:

Only a short space before the end of this experimental period I first associated the idea of *mouth* with a downward curve, and the thought 'sour-stomach' came. After that the idea of *mouth* connoting *face* came and the idea that there *should be* a face surrounding the oral groove. [*C*'s italics.] Several times thereafter a mild feeling of dissatisfaction was aroused by the fact that I could not *visualize* a facial setting. The 'mouth' association—as soon as it appeared—seemed to facilitate the perception of curves.

All this was written before he had seen or known anything about the face material. Later, after instructions to attempt to forget the *mouth* association he reported that it appeared very seldom. In the main experiment he gave the following introspections:

First DL (IIA): "At first I began using the eye-brows as my fixation point but after 4 or 5 exposures decided that mouth would be more satisfactory criterion—if 'up,' smile; 'down,' frown; 'level,' neutral. . . . . Principal criterion *mouth*."

Fifth DL (ID): "Noticed some confusion at first with the new type of material —'figures.' The Gestalt of '*face*' was so well established that the idea 'face upside down' came into consciousness immediately and persisted until the observation period was about three-quarters thru, when I became aware that 'face' was gone and I was observing simply two horizontal lines—curved or straight—on the lower part of the card. On the first two cards I tried to get my cue from the 'mouth;' finding this unsatisfactory I adopted the 'eyes' as my criteria and continued so until the end of the day's observation."

The most definite case of lower DL for expression than for curvature was that of *H*, as can be seen from Fig. 3. His introspections are correspondingly interesting.

First DL (IB): "Instead of making my judgments solely upon the direction of curvature, I frequently made them upon the basis of the 'general impression' which the individual stimulus left upon me. If the face looked pleased, it was 'Up;' if it looked displeased or as if it wore a frown, the judgment was 'Down.' If the face appeared to have neither of these expressions, it (the judgment) was 'Straight.' [Note that this was written without *S*'s knowing that he would later be asked to judge expression.] After the intermission I tried to hold myself more rigidly to the judgment of curvature alone, and during the remainder of the period I felt that I was making a greater number of 'Straight' judgments than before. [Not in accordance with the facts—the relative number of 'straight' judgments was almost exactly the same for the periods before and after the intermission.] The degree of subjective assurance was considerably less; and I felt that while fixating the 'mouth,' the other features were getting into consciousness by indirect vision, and thus influencing my judgment, somewhat as previously, by the method of 'general impression.'"

First DL (IB)—second sitting: "I tried to make all my judgments on the basis of curvature of mouth alone, but, as before, I felt that in many cases I was influenced by the 'general impression' which the diagram made. I found it difficult sometimes to fixate the mouth alone, as that frequently caused a blurring and I could report neither 'up,' 'down,' nor 'straight.' It seemed, in some exposures, that not only was the mouth curved, but the eyes as well. This circumstance is probably a function of the whole *Gestalt* (*i.e.* pattern) itself."

Second DL (IIA): "The change in *Aufgabe* today had the effect of modifying the *Einstellung*, in that a specific judgment as to curvature of the mouth was not required, but rather a judgment of *general impression*, in terms of 'smile,' 'frown,' or 'neutral.' As other features than the mouth may contribute to these characteristic expressions, the whole facial pattern was involved in my responses. The exposures are, of course, too short to permit of anything like analysis, and, as I can not, at least not often, re-image the diagram, the response must be made on the basis of something like 'snap' judgment. While I cannot be certain that other features besides the mouth are contributing to the 'general impression,' I sometimes believe they are. However, I am sure that the curvature of the mouth, when definitely perceived, is the deciding factor in many of my judgments."

Third DL (ID): "While the reversal of the figure minimized the apperceptive tendency to interpret it as a face, yet it was still a *face*; and the criterion, which has characterized the majority of my judgments, namely, a rather indefinite 'general impression,' seemed still to operate. To me, this belief was reinforced by the fact that I experienced considerable confusion at first in reporting the judgments. If the horizontal lines were turned down on the inverted figure, I had the impression of a 'smiling face,' which previously had been reported 'up,' or 'smile.' And on several occasions, these were my reports, which I immediately asked to have changed to 'down.'"

Since these introspections were written not as the result of specific questioning, but merely under instruction to write anything *S* deemed important (*H*, indeed, wrote several of his without being asked to do so), it seems significant that the two *S*s, *H* and *C*, for whom the DL for expression tended definitely to be lower than those for curvature, should have been just as definitely the only two for whom the effect of expression in the diagrams was very striking. Further, the fact that *any* of the *S*s should have given lower DL for

expression than for curvature is rather astonishing, when we remember our consideration of the *neutral* category as compared with the relative inelasticity of the *straight* category. Hence, while the inconclusiveness of the results from the statistical point of view must be admitted, the writer nevertheless believes it strongly suggested that the difference threshold for perception of facial expression in diagrams *can* be lower in the same individual than that for the perception of curvature.

From results as indecisive as those of the present experiment it would be extremely rash to draw inferences of a general nature; yet, because of the importance of the problem to the theory of perception, it is well to indicate briefly what would be implied in the outcome of such an experiment if it *were* possible to generalize. In the case that results (like *A*'s) were the rule, we should conclude that an attitude predisposing *S* to perceive the parts rather than the whole of a configuration favors the lowering of the differential limen, which very likely would be quite acceptable to the adherents of atomistic hypotheses. If, again, we found no valid differences to exist in the results (such as *Ot*'s), the descendants of Locke would be nothing dismayed. But how would this school explain lower thresholds for the perception of the configuration as a whole than for the perception of any part of that same configuration (toward which tend the results of *R*, *C*, and *H*)? What is present to assist the perception of the configuration, and not present to aid the perception of a part, unless the configuration itself?

Conclusions

(1) Thresholds for the perception of difference in facial expression and in the curvature of lines were obtained with diagrammatic material. A high degree of variability is present in the results.

(2) 'Practice effect'—the tendency toward progressive lowering of the DL—was present, though relatively slight.

(3) The 'precision' in general increased during the course of the experiment, and the increase was greater, though more variable, for curvature than for expression.

(4) The 'precision,' as a rule, was greater for curvature than for expression.

(5) The middle category of the expression judgments (*neutral*) was found to be more elastic than the middle category of the curvature judgments (*straight*).

(6) For one *S*, DL for curvature were consistently lower than those for expression. For another, the results were indecisive. For a third, the DL were lower at first for curvature but later for expression For two *S*s, the DL for expression were in general lower than those for curvature; and these two were shown by introspective evidence to have had strong tendencies toward perception of the face as a 'whole.'

(7) All *S*s agreed without instructions upon the direction of curvature present in the 'smile' and in the 'frown' respectively.

(8) The DL were lower, on the whole, for material in which three lines varied than for that in which but one line varied. This was particularly true in the DL for expression.